

REMARKS

No substantive changes have been made to the subject matter of the specification. An amendment to the paragraph starting at page 10, line 9, corrects an obvious transcription error. The incorrectly transcribed word "services" has been replaced by the word "surfaces". It is clear from the sentence preceding the sentence in which the corrected word is located that "surfaces" was taught in the specification as filed. Similarly, an amendment to the paragraph starting at page 13, line 4, corrects a transcription error by changing the word "to" to "tube".

Claims 1 – 20 have been canceled.

New claims 21 – 47 are pending.

New independent claim 21 claims a method of cleaning a ruthenium-deposition apparatus and contains the limitation of providing carbon monoxide gas in at least a portion of said ruthenium-deposition apparatus. Support for this limitation is found in the specification at, among other places: original claims 1 – 3, 6, and 7; page 5, lines 8 – 15; page 5, lines 24 -- 27; page 8, lines 21 – 23; page 15, lines 4 – 8, lines 26 – 29; page 16, lines 26 – 28; page 16, lines 25 – 26. Independent claim 21 also contains the limitation of maintaining at least said portion substantially free of an activated oxygen species and an oxygen-atom donating gas. Support for this limitation is found in the specification at, among other places: page 4, lines 1 – 12 together with page 3, lines 8 – 14; page 11, lines 18 – 29; page 13, line 29 – page 14, line 2, together with page 18, lines 14 – 15 and lines 25 – 27, and together with page 13, lines 13 – 14; page 15, lines 18 – 31.

New dependent claim 22 contains the limitation of avoiding formation of RuO_4 . Support for this limitation is found in the specification at: page 4, lines 1 – 12; page 11, lines 18 – 29.

New dependent claim 23 contains the limitations that maintaining a portion substantially free of activated oxygen species and oxygen-atom donating gas comprises purging the portion with purge gas comprising carbon monoxide, wherein the purge gas contains substantially no oxygen-containing oxidizing species except carbon monoxide. Support for these limitations is found in the specification at, among other places: page 8,

lines 17 – 23; page 15, lines 3 – 8 and lines 14 – 31; page 16, lines 26 – 28; page 18, lines 25 – 27 together with lines 14 – 15; page 22, lines 3 – 16.

New dependent claim 24 contains the limitation of supplying during cleaning of a portion substantially no species selected from the group consisting of ozone, radical oxygen, a halogen-containing species, nitrogen oxide, and an activated oxygen species. Support for this limitation is found in the specification at, among other places: page 4, lines 1 – 12; page 4, line 31 – page 5, line 2; page 11, lines 28 – 29; page 16, lines 26 – 28; page 18, lines 14 – 15 and lines 25 – 27; page 22, lines 8 – 15.

New dependent claim 25 contains the limitation of maintaining during cleaning at least the portion substantially free of a strong oxidizer. Support for this limitation is found in the specification at, among other places: page 11, lines 28 – 29; page 13, lines 13 – 14; page 13, line 29 – page 14, line 2, together with page 18, lines 14 – 15 and lines 25 – 27.

New dependent claim 26 claims that the ruthenium-deposition apparatus comprises at least a portion selected from the group consisting of a ruthenium-deposition reaction chamber, a ruthenium-precursor inlet tube, an inlet manifold, and a reaction-chamber exhaust. Support for this claim is found in the specification at, among other places: page 8, lines 18 – 23; page 8, line 30 – page 9, line 1; page 15, lines 18 – 31.

New dependent claim 27 mirrors original claim 9.

New independent claim 28 claims the limitations of providing carbon monoxide gas and avoiding formation of RuO_4 . Support in the specification for these limitations is similar to that of claims 21 and 22. Support in the specification for dependent claim 29 is similar to support for claim 21. Support for dependent claim 30 is similar to that for claim 24. Support for dependent claim 31 is similar to that for claim 25.

New dependent claim 32 depending from claim 28 includes the limitation of maintaining at least the portion substantially free of a ruthenium-containing precursor. Support for this limitation is found in the specification at: page 8, lines 21 – 23; page 8, line 29—page 9, line 1; page 18, lines 25 – 27.

New independent claim 33 claims a method of inhibiting formation of a ruthenium-containing deposit on a surface of a ruthenium-deposition apparatus. Claim

33 contains the limitation of providing a ruthenium-containing precursor gas proximate to a wafer substrate surface to deposit a ruthenium-containing film on the substrate surface and the limitation of providing CO gas proximate to an apparatus surface. Support in the specification for these limitations is found at, among other places: page 4, lines 18 – 29; page 9, lines 1 – 6; page 10, lines 9 – 14 and lines 26 – 30; page 11, lines 5 – 9; page 14, lines 25 – 28; page 19, line 6 – 11.

New dependant claim 34 contains the limitation of avoiding formation of RuO_4 . Support in the specification for these limitations is similar to that of claims 21 and 22.

New dependant claim 35 contains the limitation of maintaining the apparatus proximate to the apparatus surface substantially free of an activated oxygen species and an oxygen-atom donating gas. Support in the specification for these limitations is found at, among other places: page 4, lines 1 – 12 together with page 3, lines 8 – 14; page 9, lines 1 – 6; page 10, lines 9 – 31; page 14, lines 22 – 26; page 19, line 6 – 11.

Support for dependent claim 36 is similar to that for claim 24 and is also found at: page 11, lines 4 – 9 and lines 18 – 27.

Support for dependent claim 37 is similar to that for claim 25.

New dependent claim 38 contains the limitations that the ruthenium-deposition apparatus comprises an inlet tube having inlet tube wall surfaces, and said providing carbon monoxide gas comprises flowing carbon monoxide gas through the inlet tube while flowing a ruthenium-containing precursor gas through said inlet tube. Support in the specification for these limitations is found, among other places, at: page 13, lines 8 – 10; page 20, line 30 – page 21, line 2. Support for the flow rate ratios in dependent claim 39 is found at page 13, lines 10 – 13. Support for the flow rate ratios in dependent claim 40 is found at page 14, lines 12 – 15 together with page 13, line 29 – page 14, line 2.

New dependent claim 41 contains the limitations that the ruthenium-deposition apparatus comprises a ruthenium-deposition reaction chamber and an inlet manifold connected to said reaction chamber, and that providing carbon monoxide gas comprises flowing carbon monoxide gas through the inlet manifold while flowing a ruthenium-

containing precursor gas and a reactant gas through the inlet manifold. Support in the specification for these limitations is found, among other places, at: page 13, lines 4 – 13.

New dependent claim 42 contains the limitation of maintaining the apparatus proximate to the apparatus surface substantially free of a ruthenium-containing precursor gas. Support in the specification for this limitation is found, among other places, at: page 4, lines 18 – 29; page 9, lines 1 – 6; page 10, lines 9 – 14; page 14, lines 25 – 28; page 19, line 6 – 11.

New dependent claim 43 contains the limitation of flushing a substrate holder surface with carbon monoxide gas while providing a ruthenium-containing precursor gas in the reaction chamber. Support for the limitations of dependent claim 43 is found at: page 9, lines 1 – 6; page 10, lines 9 – 14; page 14, lines 25 – 28; page 19, lines 6 – 11; original claim 8.

New dependent claim 44 contains the limitation of flushing reaction chamber walls with carbon monoxide gas while providing a ruthenium-containing precursor gas in the reaction chamber. Support for the limitations of dependent claim 44 is found at: page 9, lines 1 – 6; page 10, lines 9 – 14 and lines 28 – 31; page 14, lines 25 – 28; page 19, lines 6 – 11; original claim 7.

New dependent claim 45 contains the limitation of maintaining the apparatus proximate to the apparatus surface substantially free of a reducing agent. Support in the specification for this limitation is found, among other places, at: page 9, lines 1 – 6 together with page 8, lines 11 – 14; page 19, lines 6 – 11.

New dependent claim 46 contains the limitation that providing carbon monoxide (CO) gas proximate to an apparatus surface comprises providing substantially no oxygen-containing oxidizing species except carbon monoxide proximate to the apparatus surface. Support for these limitations is found in the specification at, among other places: page 8, line 17 – 18 together with page 9, lines 1 – 6 and page 14, lines 22 – 31; page 20, line 30 – page 21, line 4; page 21, lines 14 – 17.

Support for the temperature limitations of dependent claim 47 is found, among other places in the specification, in original claim 9.

Claim Rejections – 35 USC §102

A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. MPEP §2131, citing *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). The identical invention must be shown in as complete detail as is contained in the claim. MPEP §2131, citing *Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 1236, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Claims 1 – 2, 6 and 9 were rejected under 35 USC 102(e) as being anticipated by Nakahara et al., U.S. Patent No. 6,537,461, issued March 25, 2003 (hereinafter "Nakahara et al").

Claims 1 – 2, 6 and 9 have been canceled.

Nakahara et al. teach a method of etching ruthenium and ruthenium oxide as useful for treating the substrate surface, for cleaning the substrate, and for cleaning a reactor. Nakahara et al., column 2, lines 9 – 13.

Claims 1 – 9 of Nakahara et al. claim a process for cleaning a substrate, not for cleaning a reactor.

A process of cleaning a reactor according to Nakahara et al. provides that ruthenium or ruthenium oxide must be made to react with ozone or atomic oxygen (atomic oxygen-donating gas) to form RuO₄. Nakahara et al., column 4, lines 4 – 6 and lines 19 – 22. As noted by the Examiner, in a method of Nakahara et al., the atomic oxygen-donating gas includes, for example, at least a gas selected from the group consisting of ozone, oxygen halide, nitrogen oxide and atomic oxygen. Nakahara et al., column 4, lines 41 – 44. The atomic oxygen-donating gas may also be mixed with at least a gas selected from a group that includes carbon monoxide. Nakahara et al., column 4, lines 44 – 49. It is clear from the chemical formula of RuO₄ that a method of Nakahara et al. always requires an atomic oxygen-donating gas to generate RuO₄ from ruthenium and ruthenium oxide species.

New independent claim 21 includes the element of providing CO gas in at least a

portion of the ruthenium-deposition apparatus. Claim 21 also includes the important limitation of maintaining during cleaning at least the portion substantially free of an activated oxygen species and an oxygen-atom donating gas. This limitation distinguishes the invention of claim 21 from the teaching of Nakahara et al, which always provides an atomic oxygen-donating gas. This limitation of claim 21 also is consistent with an objective of a method in accordance with the present invention, which is to clean a ruthenium-containing deposit without generating toxic RuO₄. Dependent claim 22 includes the further limitation of avoiding formation of RuO₄. This limitation further differentiates the present invention from Nakahara et al., who explicitly teach formation of RuO₄. Nakahara et al., column 4, lines 4 – 7; Table 1 in column 8. Dependent claim 23 claims a purge gas comprising CO that includes substantially no oxygen-containing oxidizing species except CO. Dependent claim 25 further includes maintaining the portion substantially free of strong oxidizer. Examples of strong oxidizers are taught in the specification at page 13, line 31 – page 14, line 1. Thus, claims 21 – 27 include limitations that differentiate embodiments of the present invention from the teaching of Nakahara et al.

New independent claim 28 includes the element of providing carbon monoxide gas in at least a portion of the apparatus and also includes the important limitation of avoiding formation of RuO₄. The limitation of avoiding formation of RuO₄ clearly differentiates the invention of claim 28 from Nakahara et al. The added limitations of dependent claims 29, 30 and 31 substantially mirror the limitations of claims 21, 24 and 25, respectively.

New independent claim 33 claims a method of inhibiting formation of a ruthenium-containing deposit on an apparatus surface of a ruthenium-deposition apparatus during deposition of a ruthenium-containing film on a wafer substrate. Independent claim 33 includes the limitations of providing a ruthenium-containing precursor gas proximate to a wafer substrate surface while providing carbon monoxide (CO) gas proximate to an apparatus surface. In contrast, Nakahara et al. do not teach or otherwise disclose providing a ruthenium-containing precursor. This is because Nakahara et al. teach methods for etching and removing ruthenium or ruthenium oxides, but not for depositing ruthenium.

Dependent claims 34 includes the additional limitation of avoiding formation of RuO₄. This further differentiates the present invention from the teaching of Nakahara et al., which teaches the necessity of forming RuO₄. The limitations of claims 35, 36, 37 and 46 substantially mirror the limitations of claims 21, 24, 25 and 23, respectively, and differentiate the claimed embodiments from the teachings of Nakahara et al.

For these reasons, it is believed that new claims 21 – 47 are not anticipated by Nakahara et al.

Rejections Under 35 USC §103

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all of the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed.Cir. 1991). MPEP 2142 and MPEP 2143 - 2143.03.

Furthermore, if the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious. MPEP 2143.01, citing *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1951).

Claims 3 – 5, 7 – 8 were rejected under 35 USC 103(a) as being unpatentable over Nakahara et al. in view of Lo et al., U.S. Patent No. 6,003,526, issued December 21, 1999 (hereinafter "Lo et al").

Claims 3 – 5, 7 – 8 have been canceled.

The Examiner suggested on page 6, third paragraph, of the Office Action that it would have been obvious to incorporate the steps of flowing or purging the cleaning gas through the apparatus as disclosed by Lo et al. into the process of Nakahara et al. for the

purpose of evenly providing the cleaning gas into the apparatus. As explained above, however, the process of Nakahara et al. does not include important limitations of new independent claims 21, 28 and 33 and of their depending claims. Similarly, the combination of Nakahara et al. with Lo et al. does not teach or suggest all of the claim limitations of new independent claims 21, 28 and 33.

With regard to claims 21 and 28, Lo et al. teach flowing O₂ gas, but do not teach flowing carbon monoxide. With regard to claim 33, Lo et al. do not teach flowing a Ru-containing precursor into an apparatus.

For the reasons explained above, and since claims depending from allowable claims are also allowable, it is believed that new claims 21 – 47 are in condition for allowance and their consideration and allowance is respectfully requested. If the Examiner believes that a telephone conference would facilitate formulation of the claims in allowable form, then a conference is also requested.

An excess claims fee of \$350 has been submitted with this paper.

Respectfully submitted,



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